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THE CONTROL OF THE CODLING MOTH AND APPLE SCAB.

IMPERIAL BUREAU OF MYCOLOGY
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BY

C. L. MARLATT,
BUREAU OF ENTOMOLOGY,
and
W. A. ORTON,
BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 19, 1906.

SIR: We have the honor to transmit herewith a paper entitled "The Control of the Codling Moth and Apple Scab," by C. L. Marlatt, of the Bureau of Entomology, and W. A. Orton, of the Bureau of Plant Industry.

This bulletin deals only with the two principal enemies of the apple, namely, the chief insect enemy, the codling moth, and the principal fungous disease, the apple scab. The reason for such joint publication arises from the fact that the remedial treatment for both of these is of such a nature that the applications can be combined at a lessening of nearly one-half the cost of time and labor. The bulletin includes a brief but plain statement of the nature of the codling moth and the means of controlling it, followed by a similar portion relating to the apple scab, and concluding with the combined directions for spraying, and a spray calendar. We recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. HOWARD,
Chief Bureau of Entomology.
B. T. GALLOWAY,
Chief Bureau of Plant Industry.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE CONTROL OF THE CODLING MOTH AND APPLE SCAB.

INTRODUCTION.

The codling moth or apple worm and the apple scab have no direct relationship except that both attack the apple and are, respectively, the chief insect enemy and the chief fungous disease of this fruit. Both are, however, subject to practical control by sprays, which being necessary at the same dates, in the main, can be combined in single applications, and it is for this reason that they are considered together in this bulletin. A brief life history is given of the codling moth, with a description of the sprays and other remedies for it, followed by similar matter on the apple scab. The bulletin concludes with a joint consideration, for both pests, of spraying outfits and methods, with directions for the combination of the spray mixtures, and a spray calendar.

THE CODLING MOTH.

(*Carpocapsa pomonella* L.)

LOSSES DUE TO THE CODLING MOTH.

The codling moth or apple worm is a familiar pest to every grower or consumer of apples, and a wormy apple, the result of its work, scarcely needs description. The larva, living most of its life within the fruit, throws out through its entrance hole, which it enlarges from time to time, or through its exit hole in the side of the fruit, the characteristic mass of frass or excrement which is the sign of infestation. Such an apple is practically unsalable or, at best, fetches a very small price, either for consumption or for working up into cider. The monetary loss thus occasioned by this insect is greater than that due to any other insect pest affecting fruits.

It has been shown by careful estimates in various apple-growing States that this insect may cause a loss of from 20 to 40 per cent of the fruit which would otherwise be sound and merchantable. Without going into details, this loss, on the lowest or 20 per cent basis, amounts annually to $11,400,000 in the United States, and this does not include the expenditures for spraying trees with arsenicals, which

amount to more than $8,000,000 additional, indicating a total loss chargeable to the codling moth of nearly $20,000,000. Great as this loss still is, it has been very much limited by measures of control which are becoming more and more widely adopted, and many apple growers in badly infested regions are now saving every year more than 85 per cent of fruit which would, without treatment, be wormy.

The following account of the codling moth, with directions for control, is abbreviated and recast from Farmers' Bulletin No. 171, by Mr. C. B. Simpson, formerly a special agent of the then Division of Entomology, who made a three years' investigation of the codling moth in the Northwest.

DISTRIBUTION.

The original home of this insect was probably southeastern Europe, the home of the apple, but it has followed closely upon the distribution of the apple until it is now found in almost every country in the world. It is spread principally by the shipping of the infested fruit. The young larvæ in such fruit complete their development, and, leaving the fruit, spin cocoons on the crates or near by, the moths emerging in due course and flying to the nearest orchard to deposit their eggs. When orchards are but a little distance apart the moths may fly from one orchard into another.

FRUITS INFESTED.

The apple is the natural food of this insect, and sustains almost all the loss occasioned by it. Pears are next in order of infestation, but if apples are present in the same orchard, pears are usually not badly infested. The codling moth larvæ have been found also in the fruit of quince, prune, plum, peach, and cherry, but never in sufficient numbers to cause any great injury.

LIFE HISTORY.

Every fruit grower should familiarize himself with the different stages of this insect by studying it in his own orchard, so that he will understand the principles of control, which are based on certain vulnerable points in its life cycle.

Hibernation.—The codling moth passes the winter in the larval stage in silken cocoons in cracks and holes in the trees and in houses where apples have been stored. In the spring these larvæ change to pupæ, and the moths emerge about a month after the apple is in blossom.

The moth.—The moth (fig. 1, *a*) is but little known among fruit growers, and other moths are often mistaken for it. It varies somewhat in size, but the maximum spread of its wings is about three-fourths of an inch. The front wings are of a brownish gray color

and are crossed with lines of gray scales, giving them the appearance of watered silk. At the tips of the wings there is a large brown spot, in which are many scales of bronze or gold. The hind wings are grayish brown in color. Taken as a whole, the coloring of the moth is such that when resting on old grayish bark it is so like the bark that it is not easily distinguished. The moth lays her eggs, a few days after emergence, on the leaves of apple or other food plant, or on the fruit. A majority of the eggs of the first generation are laid on the leaves, while the greater part of those of the second generation are laid upon the fruit.

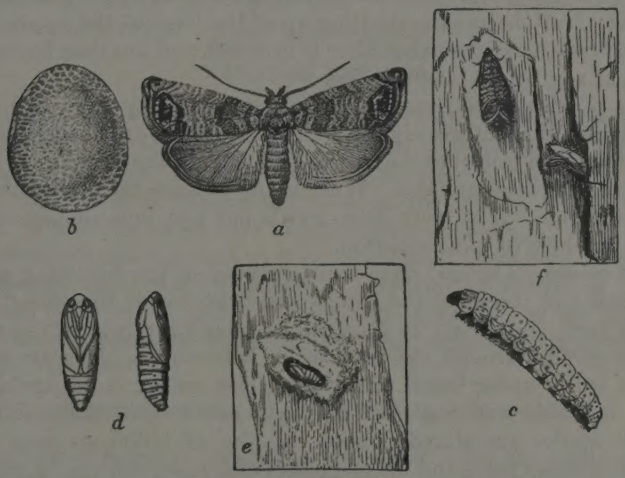

FIG. 1.—The codling moth: *a*, the moth or adult insect, slightly enlarged; *b*, the egg, greatly enlarged; *c*, the full-grown larva, slightly enlarged; *d*, the pupa, slightly enlarged; *e*, the pupa in its cocoon on the inner surface of a piece of bark, reduced about one-half; *f*, moth on bark and empty pupa skin from which it emerged, about natural size (from Simpson).

The egg.—The eggs are very minute, scarcely visible to the naked eye, and pearly white in color, resembling thin convex disks. Around the edge there is a coarse network of ridges; while toward the center these ridges are finer, as illustrated in fig. 1 at *b*. A red ring, which indicates the embryo or developing larva, appears in the egg a few days after it is laid. In about eleven days, varying somewhat with temperature, the young larva breaks its way out of the shell and seeks to enter the fruit.

The larva.—This is the most important stage of the insect, for not only does it work its injury in the larval condition, but that is the stage in which it is most amenable to remedial measures.

A large number of the larvæ which hatch from eggs deposited on the leaves eat small portions of the leaves before finding fruit. The

larvæ have some difficulty in entering the smooth sides of the fruit, and about 80 per cent of the first generation enter by way of the calyx, while the majority of the second generation enter at the sides, especially where the fruits are touching.

Before entering the young apple the larva feeds, as noted, on the leaves, but also for a day or two within the partial concealment formed by the calyx or blossom end of the apple. During several days, therefore, the little apple worms feed externally, both before they enter the calyx and within the latter, and the object of spraying is to insure their being poisoned by thoroughly coating in advance, with an arsenical mixture, the leaves, and especially the blossom end of every fruit, before the shutting up of the lobes of the calyx. Most of the larvæ enter the calyx after it is closed, and are then beyond the reach of any poison later applied.

The pinkish larva lives in the fruit about twenty days, and grows to a length of about five-eighths of an inch (fig. 1, *c*), when, being full fed, it makes a tunnel to the outside of the fruit, the entrance of which is filled with frass and silk. When ready to leave the apple this plug is pushed out. The larva then crawls out and immediately seeks a place in which to spin its cocoon.

The cocoon.—Cocoons have been observed in the following places: In holes and cracks in the trunks and branches of the trees; under rough bark (fig. 1, *e*); in the fruits (though rarely); in the cracks in the ground around the tree; on or between the clods among the fallen fruit; under bands or anything else resting on or against the tree; in cracks and angles of the walls and roof of the building in which apples are stored; under shingles of buildings near apple trees; in fence posts and under pickets of near-by fences; in paper or other rubbish on the ground; and in various other places. The cocoons of the first generation are composed entirely of silk, while in those of the second generation are incorporated bits of wood and bark. The larvæ inside the cocoons transform into pupæ in about six days from the time of spinning the cocoon.

The pupa.—The pupa (fig. 1, *d*) is yellowish at first, but changes to a brown, and later to a bronze color. In about twenty days from the spinning of the cocoon the pupa, aided by its spines, pushes its way out of the cocoon. The pupa skin splits and the moth emerges (fig. 1, *f*), lays its eggs, and gives rise to another generation. The average life cycle of the insect is about fifty days.

GENERATIONS OF THE INSECT.

In the principal northern apple-growing sections of the United States, as, for example, New York and Maine, the insect has but one full generation, with only a partial second. In the warmer portions of the East and West two generations are found, and in the Southwest

and South a partial third generation has been distinguished. Where two full generations occur, the members of the second are much more numerous and destructive than those of the first. The dates of the different generations will vary in a given locality with the season. Taking Nebraska as representing the upper Mississippi Valley region, the first brood of the codling moth will pass from the egg to the moth stage between June 1 and August 15, the majority of the moths emerging between July 20 and August 15. The second generation overlaps the first, beginning in the egg stage about the end of July and running on to the end of the season, the larvæ of this generation hibernating. In the Southwest some of these larvæ may transform to moths and give rise to a partial third generation.

NATURAL ENEMIES.

There are many natural enemies of the codling moth which may be encouraged with advantage. It has often been noted that no larvæ can be found under the rough bark of the trees in the spring, while many are found in cracks and holes in the trunks, branches, and stubs. Under the rough bark many cocoons can be found from which the larvæ are missing, and in these cases the telltale hole made by a woodpecker can always be found. Destroying or rendering unsuitable the more secure places for spinning, thus forcing the larvæ to spin cocoons where the birds can get them, will result in destroying many of the insects.

MEASURES USED AGAINST THE CODLING MOTH.

The first essential in combating this insect is for the apple grower to familiarize himself with its life history. By doing this he is better prepared to understand the remedial measures recommended, and can modify them to suit his local conditions.

Remedies of Little or No Value.

It is sometimes as well to know what not to use against an insect as it is to know what to use. The following remedies have been suggested at various times and found to be of little or no value: Moth balls hung in the trees and supposed to keep moths away; smudging or spraying orchards with ill-smelling compounds; plugging the trees with sulphur; plugging the roots with calomel; banding trees with tarred paper to keep the larvæ from crawling up the tree; trap lanterns; baiting the moths with a mixture of vinegar and molasses; spraying with water; and electric lights as a repellant of the moth. These so-called remedies have been tried so often that a fruit grower is simply wasting his time and money when he uses them.

Banding.

The use of bands to trap the full-grown larvæ of the codling moth was the only remedial measure of value employed before arsenical sprays were discovered. If an orchard has been given good care, and spraying is thoroughly done, it may be unnecessary to use bands. If, however, the trees are old and cracked, and have holes in the trunks and branches, or are planted close together, so that spraying is difficult, the use of bands will materially aid in bringing the insect under control.

FIG. 2.—Large apple tree properly banded for the codling moth (from Simpson).

Banding for this insect is simply affording it a good place to spin its cocoon, and killing the larva or pupa after it has gone beneath the band. Cloth bands, from 10 to 12 inches in width, are folded once lengthwise and placed around the tree. They can be fastened in such a way as to be easily removed and replaced, by driving a nail through the ends and then nipping off the head at an angle so as to leave a sharp point. If a tree is large, one band should be placed on the trunk and one on each of the larger limbs (fig. 2). Cloth bands of any heavy, dark-colored stuff are much preferable to bands of hay or paper. When bands are used, the trees should be scraped clean of rough or loose bark, to leave as few other attractive places as possible in which the larvæ might spin cocoons. Inspection of the bands should be made regularly at intervals of ten days, and all larvæ and pupæ found beneath them should be destroyed with a knife. If used alone, banding is but little effective in badly infested localities, but it is a most valuable adjunct to spraying. Under no circumstances should banding be used as a substitute for spraying.

Spraying with Arsenical Insecticides.

Spraying with some arsenical is now recognized as the best means of controlling the codling moth. The object, as noted elsewhere, is to poison the young larvæ before they enter the fruit. The larvæ get the poison while feeding on the leaves, or in the calyx, or on the sides of the fruit, and are killed. There are several of the arsenical compounds upon the market, and others which the fruit grower can prepare himself. The most available and best are described below.

Paris green.—Paris green is probably the best known of these arsenicals. It is a definite chemical compound of arsenic, copper, and acetic acid, and should have a uniform composition. It is a rather coarse powder, and has the fault of settling rapidly. It costs about 20 cents a pound, but varies in price from year to year with the fluctuation in the cost of the ingredients. It may be prepared for spraying as follows:

Paris green	pounds	1
Lime	do	3
Water	gallons	150

The lime should be fresh and should be slaked in quantities as required. Mix the Paris green with a little water until a paste is formed, and then add this to the required amount of water, to which the lime has been added. A good average strength to use is 1 pound to 150 gallons, but it must be weaker on trees with delicate foliage. Many fruit growers are using it on apple trees as strong as 1 pound to 100 gallons.

Scheele's green.—Scheele's green is similar to Paris green, but differs from it in lacking the acetic acid. It is a much finer powder than Paris green and more easily kept in suspension, and it costs only about one-half as much. It is employed in the same way as Paris green.

Arsenate of lime with soda.—In the preparation of this insecticide the following formula may be used:

White arsenic	pounds	1
Sal soda (crystal)	do	4
Water	gallons	1

The above ingredients are boiled until dissolved, which will be in a very few minutes, and the water lost by evaporation is then replaced. To 40 or 50 gallons of water a pint of this stock solution and 3 to 4 pounds of freshly slaked lime are added. This excess of lime is always desired by fruit growers, as they can then see by the amount and distribution of the lime on the foliage how well the spraying has been done. This formula has been thoroughly tested and has been found to be not only as efficient as the other solution, but far cheaper.

Precautions to avoid poisoning.—At all times the greatest care should be taken to prevent accident with these compounds, which are of the most poisonous nature. All packages, boxes, or bottles containing these materials should be plainly labeled and kept under lock. The utensils with which the mixtures are prepared should be thoroughly cleansed after use.

The method of application, spraying dates, and the apparatus to be used, are discussed together for both the codling moth and the apple scab on pages 16–21.

APPLE SCAB.

LOSSES DUE TO APPLE SCAB.

Apple scab is perhaps the most destructive fungous enemy of the American fruit grower, particularly in the North, occupying among diseases a position ranking with that of the codling moth among the insect foes of the apple. Its injuries are greater than are generally appreciated, both in effect and extent. The yield of fruit per tree is greatly lessened whenever scab is present: (1) By the premature dropping of young apples, due to the attacks of the scab fungus on flowers, stems, and fruits soon after the blossoms fall; (2) by the smaller size of the scabby apples that mature, and (3) by the loss, just before picking, due to the fact that scabby fruit does not cling well to the tree and is more easily blown off; (4) the value of the fruit harvested is greatly diminished, since spotted apples must be placed in a lower grade and sold for less than clean fruit; (5) their keeping quality also is impaired, as molds and other fungi which cause decay gain entrance through the scab spots and increase the loss during storage. Nor is the damage confined to the fruit. The leaves also are attacked by the fungus, and the resultant spotting and distortion considerably lessen the vigor and general health of the tree.

The aggregate loss from scab is enormous, amounting to many millions of dollars every year. This is a most oppressive tax on the farmer, since it is unnecessary. An effective remedy is available in Bordeaux mixture. The experience of many years has demonstrated that the loss from scab may be almost entirely prevented by thorough and timely spraying, which is considered by the leading fruit growers throughout the country to be an indispensable orchard practice.

CAUSE.

Apple scab is caused by the summer or conidial stage[a] of a fungus found in its perfect form[b] on dead apple leaves. The disease appears first on the leaves shortly after they unfold, the first infec-

[a] *Fusicladium dendriticum* (Waller) Fckl.

[b] *Venturia inæqualis* (Cke.) Ader.

tions having come from spores blown by the wind from the dead leaves of the previous season. The olive green, velvety spots on the leaves and fruit produce great numbers of spores, which spread the scab broadcast. In a favorable season the flowers and very young fruit and its pedicels are attacked also. The fungus grows in this manner throughout the summer and autumn. In late autumn and winter the Venturia or perfect stage is produced on the dead apple leaves on the ground.

The relative severity of the disease is influenced by a number of factors, chief of which is the weather. A low temperature and abundant moisture favor the development of the fungus, and consequently scab is worse in cool, damp seasons.

Cultural conditions in the orchard influence the scab fungus as much as they do the codling moth. Neglected, unpruned, and uncultivated trees are more subject to scab, and careful attention to the general condition of the orchard will always be profitable in connection with spraying.

Varieties of apples differ somewhat in their susceptibility to scab, though not to an extent that will make it worth while to plant resistant varieties with the idea of avoiding the necessity of spraying.

HOW TO MAKE AND USE BORDEAUX MIXTURE.

For spraying apples, the following is a formula which has given good results:

Copper sulphate (bluestone)	pounds	4
Lime	do	5
Water	gallons	50

When the apple scab is bad and the season wet, 5 pounds of the copper sulphate should be used.

The following paragraphs on making and using Bordeaux mixture and on types of spray outfits are quoted from a recent bulletin prepared in the Bureau of Plant Industry:[a]

Method of Making Bordeaux Mixture in Small Quantities.

Where only a small quantity of Bordeaux mixture is required—from a bucketful to a barrel—the method described by Dr. B. T. Galloway in Farmers' Bulletin No. 38 gives excellent results. Two half-barrel tubs are made by sawing a barrel through the middle. One tub is used for the bluestone solution and the other for the milk of lime, and each tub should contain 23 to 25 gallons. One man dips the bluestone solution with a bucket and pours it into a barrel or other vessel, and another man simultaneously dips up and pours in bucketfuls of the milk of lime (fig. 3). The lime solution should be kept well stirred. If only a single barrel is to be made, the materials may be dissolved in the dilution tubs;

[a] Farmers' Bulletin No. 243.—Fungicides and Their Use in Preventing Diseases of Fruits. By M. B. White, pathologist in charge of investigations of diseases of fruits.

but if a number of lots are required, the materials can be kept in stock solution (see p. 15) and simply transferred by dipping. In preparing very small quantities of Bordeaux mixture, buckets or similar vessels may be substituted for the half-barrel tubs. It is possible for a single operator to dip a bucketful of the bluestone solution and then a bucketful of milk of lime and pour them together into a vessel. It is usually preferable to have a bucketful or so of water in the receptacle into which the solutions are to be poured, but this is not essential.

FIG. 3.—Making Bordeaux mixture.

The better and quicker way of making up Bordeaux mixture by the barrel consists in placing the two half-barrel tubs on an elevated platform and then, by means of hose or spigots, allowing the two solutions to flow together into a barrel. This method is more fully described farther on.

Straining the materials.—No matter what quantity of mixture is to be made up, it is necessary to strain the materials through a wire strainer. The best type of strainer is made of brass wire, with 18 or 20 meshes to the inch. If all the copper solution is strained and then the milk of lime is strained into the dilution vessels, it will not be necessary to strain the Bordeaux mixture as, on account of its flocculent character, it is sometimes more difficult to pass through the strainer than the lime milk. Some very good strainers made of copper are on the market and may be obtained from the makers of spray pumps. One of the best, which can be made at home, is in the form of a box about a foot square (fig. 4), the bottom of which is a rather heavy board (preferably of hard wood), with a hole bored through it, into which a piece of gas pipe 1¼ to 2 inches in diameter and 8 to 12 inches long is fitted. The box is of course open at the top. Fitting just inside this box is a second and lighter box, also open at the top, and having an overhanging strip nailed around the top which supports it. The bottom of this inner box should be made so as to slope at an angle of about 30°, and should be made of wire screen. The slanting bottom makes it harder to clog with the spray, and the inner box, being movable, can be inverted and washed in a tub of water.

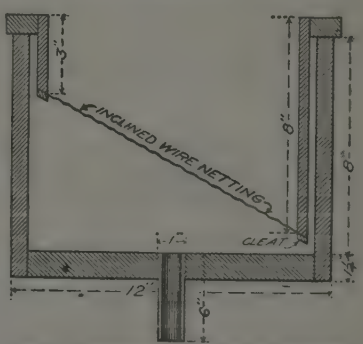

FIG. 4.—Cross section of strainer for Bordeaux mixture.

Method of Preparing Bordeaux Mixture for Large Operations.

In large operations stock solutions should always be used, as the time required to dissolve the material is saved.

Stock solutions.—These can be prepared of both the copper sulphate and the lime. They may be made by dissolving copper sulphate in water at the rate of 1 pound per gallon, and lime in the same ratio, although a strength twice as great may be used in warm weather. When stock solutions are on hand it is only necessary to measure off the required quantity of each and dilute with water before mixing. In preparing a stock solution of copper sulphate, a 50-gallon barrel may be filled about two-thirds or three-fourths full of water; then a sack, or a box with perforations over which copper wire has been tacked, containing 50 pounds of bluestone, should be suspended in the upper part of the barrel and enough water added to fill the barrel. In from twenty-four to thirty-six hours this material will be entirely in solution, and the sack or box may be removed. A slight stirring will insure the even distribution of the bluestone, after which the solution is ready for use.

The copper sulphate should be measured in a copper or granite-ware receptacle, iron or tin vessels being quickly destroyed by either copper sulphate or Bordeaux mixture.

FIG. 5.—Platform method of making Bordeaux mixture.

Use of an elevated platform.—If possible the dilution tank should be raised so high on an elevated platform that the mixture can be conducted by gravity directly into the spray tanks beneath (fig. 5). If a hillside is available, it is much the most convenient place to do the work. The platform can be arranged with a roadway on its upper side so that the lime and bluestone can be delivered there, while the spray tank is filled from the lower side.

The water supply.—A water supply of some sort is necessary; a tank filled by a windmill pump and elevated so as to be a few feet above the dilution tanks is a great advantage. Hose may be used to fill the dilution tanks, or an iron pipe with a spigot may be placed over each tank. Each dilution tank should hold half the quantity it is desired to make up at one time—that is, if a 200-gallon spray tank is to be filled the dilution tanks must hold about 100 gallons each. There is no objection to adding a few extra gallons of water, but it is better to have the tanks hold just the right quantity.

Methods of mixing the solutions.—Either of two methods of mixing can be employed: One in which the spray material is conducted directly from the dilution tanks into the spray tank and actually mixed in this tank; the other in which a mixing tank sits just below the dilution tanks and from which the spray, after being mixed up, is conducted by gravity into the spray tank. In certain ways the latter is more convenient than mixing directly into the tank, but unless the operations are somewhat extensive it will hardly justify the extra expense. In very large operations, however, a separate mixing tank is recommended—or perhaps even two of them side by side—so that batches of the mixture can be kept on hand for a few moments awaiting the spray wagons.

Testing Bordeaux Mixture.

When Bordeaux mixture is properly prepared it is of a brilliant sky-blue color. If the lime is air slaked or otherwise inferior in quality, resulting in a bad mixture, the preparation will have a greenish cast, and if this is very pronounced the mixture will injure the foliage.

In order to make certain that the copper sulphate is properly neutralized by the lime, the yellow prussiate of potash test may be used. A small bottle containing a 10 per cent solution of yellow prussiate of potash can be secured from a druggist. After stirring the Bordeaux mixture, a drop of this solution is allowed to fall on the surface of the preparation. If free copper is present, the drop will immediately turn reddish-brown in color. Lime should then be added until the brown color fails to appear. If the reaction is complete, the yellow prussiate of potash solution will remain a clear yellow until it disappears in the mixture.

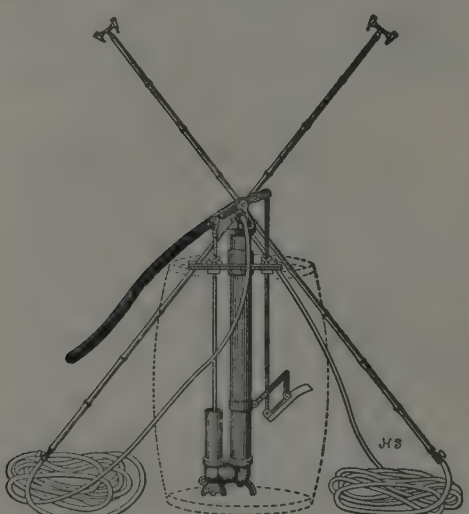

FIG. 6.—Barrel spray pump.

SPRAYING.

TYPES OF SPRAY OUTFITS.

The barrel pump.—No type of spraying outfit is more widely used or has given better satisfaction in small or medium-sized commercial plantations than the barrel pump (fig. 6). A great many different forms are now supplied by the makers of spray pumps, and a number of them are efficient and successful. They are mounted in a great variety of ways. An ordinary 50-gallon whisky or kerosene barrel forms an excellent, though inexpensive, tank for holding the spray. The pump, according to its design, can be inserted in the end or the side of the barrel. The barrel may then be mounted to suit the operator on a sled or on two wheels, or it may be placed in a cart or wagon. A small sled can be made in a few minutes by spiking some plank across a couple of pieces 2 by 4 inches, or, better, 3 by 4 inches, with the ends rounded to serve as runners. Such an outfit can be drawn through narrow rows of potatoes, vegetables, or other crops, where a wagon could not go. The ordinary 2-wheeled cart makes a very convenient rig to use with the barrel sprayer. One man can easily drive the cart and pump while one or two additional hands can apply the spray from the ground.

The tank outfit.—Various forms of tanks can be mounted on a two-horse wagon and thus enable a larger quantity of spray to be carried into the field. These tanks are sometimes square or rectangular. Some orchardists prefer to mount a large hogshead, either end up or on its side, and to pump the spray from that. As a rule, however, the best style is either a rectangular tank or

a half-round tank, flat on top. With the rectangular or half-round tank an ordinary barrel pump can be used, but it is much better to use one of the larger tank pumps especially made for the purpose (fig. 7). These can be mounted either on top of the tank or on a platform at either end. The regular tank pump has a suction of whatever length is desired, which draws the spraying mixture from the tank. One of the great advantages of the tank-pump outfit is the convenience of arranging an elevated platform. Where tall trees are to be sprayed it is almost impossible to reach the tops from the ground with extension rods of reasonable length. A scaffolding or tower of the height desired can be built on top of the wagon, and the operator can thus be elevated 10 or 12 feet from the ground. A type of the tank-pump outfit is shown in the accompanying illustration (fig. 8).

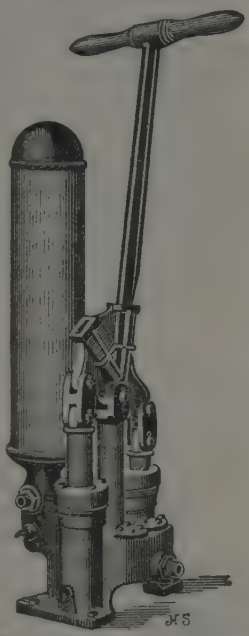

FIG. 7.—Large hand spray pump.

Geared sprayers.—In the above-described outfits the pressure on the pump is secured by man power. Ingenious fruit growers, as well as manufacturers, have devised several contrivances by which power is obtained by means of a sprocket wheel from the axle of the wagon. There are a number of different devices, several of which are more or less successful. As a rule these geared devices are better adapted to low-growing crops, like potatoes and strawberries, and possibly also to vineyards, than they are to large orchard operations, although they have been used a good deal in orchards. In spraying fruit trees the operator frequently stops long enough to thoroughly coat each tree before proceeding. Usually this can not be done with the geared sprayers, although some have provision for storing up the pressure.

Steam and gasoline outfits.—The highest type of spraying outfit consists of a steam, gasoline, or kerosene pump mounted on a wagon and drawing the liquid from a tank of from 100 to 300 gallons. Several growers use very successfully a small 2 or 3 horse-power steam boiler and a bronze steam pump. This is carried on a platform on the wagon. The only objection to such an outfit is its weight, but, on the other hand, those who have used steam sprayers seem to have less fault to find than the users of the gasoline sprayers.

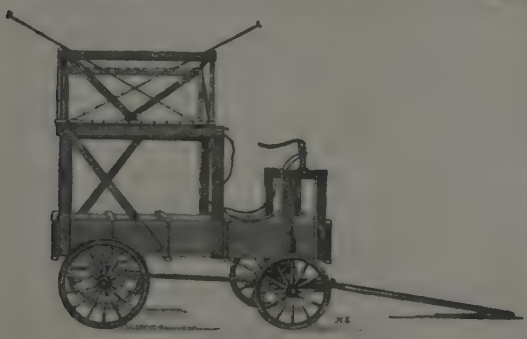

FIG. 8.—Tank outfit with hand pump.

Recently the writer has used a very successful kerosene outfit very similar to the one described above. With a gasoline or steam outfit it usually pays to have four leads of hose and four men spraying at a time.

SELECTION OF SPRAY OUTFITS.

In selecting spray pumps from catalogues, the number and size of the trees are the principal factors to be considered.

For home orchards of small size a good equipment consists of a hand barrel pump, 15 feet of ⅜-inch hose, one 8-foot bamboo extension rod, one double Vermorel nozzle; cost of outfit, $12 to $18.

For a medium-sized orchard choose a slightly larger pump of the same pattern (fig. 6), and equip it with two lines of hose, two double Vermorel nozzles, and two bamboo extension rods; cost, $25 to $30.

For a large orchard select a double-cylinder pump of large capacity (fig. 7), operated by an upright lever. Four to six leads of hose can be supplied in this way. Such an outfit, including a 100-gallon tank, costs from $75 to $90.

THE HOSE AND EXTENSION RODS.

Nothing contributes more to success in spraying operations than satisfactory hose and nozzles. In ordinary spraying operations with the barrel pump, half-inch hose is commonly used. As a rule, however, for the barrel pump three-eighths or one-fourth inch hose is better. The lighter hose is easier to handle and is less likely to kink and break. Good three-ply or four-ply hose in either case should be bought. It usually does not pay to attempt to use cheap hose in spraying. The couplings should be of a style readily adjusted in the field by means of a screw-driver, and everything must be kept tight to withstand pressure, especially in case of the power outfits.

FIG. 9.—Vermorel spray nozzle.

The ends of the hose should be attached to extension rods of suitable lengths for the work. (See fig. 6.) Occasionally in getting up a very cheap outfit one-fourth-inch iron gas pipe may be used. It is heavy and clumsy, however, and is only a temporary expedient at best. For all lengths above 6 feet a bamboo extension rod is recommended. This consists of a small brass tube supported by a bamboo rod.

The most important part of the whole apparatus is the nozzle. Unfortunately this feature has been much neglected by pump manufacturers, and many inferior nozzles have been sent out to farmers. There is a tendency to improvement in this direction in the past two years, however. Good results in the application of the spray mainly depend upon the efficiency of the nozzle. For most purposes the best nozzle is the Vermorel, or a nozzle of that type (fig. 9).

METHOD OF SPRAYING.

Thorough work essential.—It is most important that spraying should be done thoroughly. Most of the failures are due to superficial work. The whole surface of every bud and leaf should be covered. Any portion left unsprayed is subject to the attack of the scab fungus or may allow a codling-moth larva to escape.

Overspraying to be avoided.—The operator should endeavor to deposit the spray in the form of a fine mist, covering the leaves with small drops, and should be careful to stop at this point, viz, before the mixture collects in larger drops and drips from the tree. Less will be left on the leaves if the spraying is continued too long and an unnecessary amount of the mixture is used.

COST OF SPRAYING.

The cost of spraying varies so greatly under different conditions that only approximate figures can be given. The varying factors are the wages and efficiency of the labor employed, the capacity of the spraying outfit (the work can be done cheaper with a large outfit than with a small one), the size and condition of the trees, the conveniences provided for preparing and holding the mixture, the nearness to water, etc., and, lastly, the cost of materials.

The cost of the different arsenicals varies rather widely. Lime arsenite with soda is cheapest, its cost being little more than one-quarter that of either Paris green or lead arsenate and about one-half that of Scheele's green. The fruit grower can judge for himself whether it is worth his while to go to the trouble of home preparation of the cheaper arsenicals.

Bordeaux mixture prepared fresh at home is both cheaper and more effective than the ready-made article. The farmer should by all means make his own mixture. Bluestone fluctuates in price, but is obtainable in moderate quantities for about 7 cents per pound.

Materials for spraying 100 trees with Bordeaux mixture and arsenicals can be had for from $2 to $3. The cost of application is likely to equal the cost of the materials. Records of the actual expense incurred in spraying orchards vary from 10 cents to 30 cents per tree for the entire season's work of three to six sprayings.

SPRAY INJURY TO FOLIAGE OR FRUIT.

No injury should result from the sprays recommended in this bulletin if properly prepared and applied, though such injury is occasionally reported to occur under unusual weather conditions or when mistakes have been made. This is indicated by the burning of the leaves, especially of the tips and margins, and a russeting of the

fruit. To avoid this injury, follow directions exactly. Take special care to have the lime pure and freshly slaked. An excess of lime will do no harm and should be used if any spray injury is observed. Do not use more bluestone or arsenical than advised.

WHEN TO SPRAY FOR THE CODLING MOTH AND THE SCAB.

It is practicable to combine most of the sprayings for the codling moth and the apple scab and thus lessen by one-half the cost in time and labor. The arsenical may be added to the diluted Bordeaux mixture at the same rate as to pure water, and the lime in the Bordeaux mixture will act as an additional preventive of scalding from the arsenical and obviates the necessity of adding lime to take up free arsenic. The dates of spraying for the first brood of the codling moth and for the apple scab are the same except for the first treatment for the scab, which should be made after the leaf buds unfold but before the flower buds open, and is the most important application for this disease. The arsenical in this first application has no relation to the codling moth, which has not yet appeared, and it is sometimes omitted; but its addition costs very little, and it will reach the canker-worm, bud moth, and curculio. The subsequent sprayings apply to both the codling moth and the apple scab, and the arsenical should always be added to the Bordeaux mixture. The second spraying should be made just after the blossoms fall and before the calyx closes, and is the most important of the sprayings for the codling moth, getting the poison into the open calyx, where it will subsequently destroy the larvæ before the latter can penetrate into the apple. The third and fourth combined sprayings should follow at intervals of fifteen days. In the case of the codling moth these destroy the young caterpillars on the leaves before they reach the fruit and in their feeding about the calyx, and assist in the control of the apple scab. A fifth combined spraying may be given thirty days subsequent to the fourth, but this is optional in the case of both pests and will depend on the amount of probable infestation of either codling moth or apple scab.

Later sprayings against the codling moth are directed against the larvæ of the second generation when they are entering the fruit, and need not be combined with the Bordeaux treatment for the scab. The time for this spraying for the codling moth will vary with locality and seasons. The larvæ of this second generation enter the fruit beginning with the last of July and extending through August and September. The number of sprayings to be made against this second generation depends upon the efficiency of the preventive measures and of the early sprayings. Two of these later sprayings are usually sufficient, and may be made, respectively, during the last week in

July and about the middle of August. The quantity of lime used in the last spraying should be reduced to not more than 1 pound to the pound of arsenical to avoid a limy coating on the ripe fruit.

Light showers have but little effect in washing away the spray, but a continued rain or heavy shower may make it necessary to repeat the application.

SPRAY CALENDAR.

For the convenience of orchardists and others, the materials to be used at each spraying and the times for applying the same to secure the best results have been arranged in the following tabular form:

Number of application.	Material.	Time of application.
First	Bordeaux mixture and arsenical	After leaf buds unfold and before flower buds open.
Second	Bordeaux mixture and arsenical	Just after petals fall.
Third	Bordeaux mixture and arsenical	15 days later. (This may be omitted in dry seasons, and in dry States like Nebraska.)
Fourth	Half-strength Bordeaux mixture and full-strength arsenical.	30 days after petals fall.
Fifth	Half-strength Bordeaux mixture and full-strength arsenical.	60 days after petals fall (optional).
Sixth	Arsenical	July 25.
Seventh	Arsenical	August 15.

The first and second applications are the most important in controlling the apple scab, and the second and fourth are most important in combating the first brood of the codling moth. The third and fifth are optional for both pests as indicated, and the sixth and seventh are for the second brood of the codling moth only, and have no relation to the scab.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number and title of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.

No. 22. The Feeding of Farm Animals. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds: And How to Kill Them. No. 29. Souring and Other Changes in Milk. No. 30. Grape Diseases on the Pacific Coast. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Culture and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 41. Fowls: Care and Feeding. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 54. Some Common Birds. No. 55. The Dairy Herd. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. Insect Enemies of the Grape. No. 71. Essentials in Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 91. Potato Diseases and Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. 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